## APPENDIX A

**"CLEAN" VERSION OF EACH PARAGRAPH/SECTION/CLAIM**
**37 C.F.R. § 1.121(b)(ii) AND (c)(i)**

## SPECIFICATION:

Replacement specification follows:

REVISED SPECIFICATION

# REVISED SPECIFICATION

## MANUFACTURE OF A MULTI-LAYER MATERIAL AND MATERIAL THUS OBTAINED

## BACKGROUND

### Field Of The Invention

The present invention refers to manufacture of a multi-layer material and to the material thus obtained.

### Relevant Art

The multi-layer materials are useful in many different fields and particularly in the packaging industry. One such material is corrugated cardboard. Typically, the corrugated cardboard is produced by covering a sheet, which is first corrugated by passage between two fluted cylinders, with two cover sheets which are adhered to the tops of the central sheet corrugations.

In the packaging industry, the corrugated cardboard finds its main use as particularly effective protective material, and has the added benefit that is relatively easy to recycle.

Relatively thin corrugated cardboard is also used as an attractive packaging material for a special range of products. It is necessary, in this case, to print this corrugated cardboard. This printing process is possible thanks to the progress reached with flexographic printing techniques which allow high quality printing in several colors.

A known problem with printing of a corrugated cardboard is that the printing will show lines corresponding to each corrugation top since, in the printing process, the corrugated cardboard will be slightly crushed. The different resistance between the top of the corrugations and the segment between two consecutive tops is the main reason these lines appear.

The manufacture of a corrugated cardboard is carried out by means of a complex machine such as a corrugating device which includes a paper feeding station, made of reels, for a corrugating station, a paper feeding station, made of reels, for a first cover sheet, a paper feeding station, made of reels, for a possible second cover sheet, a gluing device for the glue deposit on the top of the corrugations, a pressing station for the gluing of the second cover sheet on the tops of the corrugated sheet, devices for longitudinal and transverse cutting of the corrugated sheet and a delivery station for cardboard sheets cut at the requested format.

Generally, all the operations carried out on the various sheets comprised in the corrugated cardboard are carried out at high temperature, up to around three hundred degrees, and often in a wet ambient.

Aside from the indicated printing problems, corrugated cardboard shows a bad mechanical resistance in a direction parallel to the corrugations and it is very often "warped"; i.e. curved, and therefore difficult for the printing and the die-cutting machines to handle. Also, the corrugations require a significant quantity of paper and the gluing of cover sheets on the top of the corrugations requires also a significant supply of glue.

The processes currently used to manufacture a multi-layer material show all the above mentioned disadvantages, essentially related to the configuration of the component materials.

The aim of this invention is to overcome, at least partly, the disadvantages shown by a multi-layer material such as corrugated cardboard.

## BRIEF DESCRIPTION OF THE INVENTION

According to one aspect of the invention there is provided apparatus for manufacturing a multilayer material.

According to a second aspect of the invention, there is provided a method manufacturing a multilayer material.

According to a third aspect of the invention, there is provided a multilayer material formed of paper that can be printed without causing the underlying structure to become visible on the printed surface, and which can be made of lighter unit weight than conventional corrugated cardboard, while still exhibiting equal longitudinal and transverse rigidity.

In broad terms the apparatus according to the first aspect of the invention is comprised of a forming station including a forming mechanism operative to produce an array of outwardly projecting cells on a first side of a first paper web, a gluing station including a glue application mechanism operative to apply glue to the peaks of the outwardly projecting cells on the first side of the first web, a two-layer laminating station including a pressure-feeding mechanism operative to press a surface of a second paper web onto the glued peaks on the first side of the first paper web, and a receiving station operative to receive a laminated web exiting from the two-layer laminating station.

Apparatus according to a variation of the first aspect of the invention includes a forming mechanism operative to produce an array of further cells projecting from a second opposite side of the first paper web, a second gluing station including a glue application mechanism operative to receive a laminated web exiting the two-layer laminating station, and to apply glue to the peaks of the cells on the second side of the first web, and a three-layer laminating station including a pressure-feeding mechanism operative to press a surface of a third paper web onto the glued peaks on the second side of the first paper web, and to deliver the resulting three-layer web to the receiving station.

Further according to the first aspect of the invention, a forming mechanism may be comprised of at least one cylinder having an array of cavities on the surface thereof, and a plurality of internal passages communicating at one end with the cavities, and connectable at the other end to a vacuum source, the cylinder being rotatable and positioned to engage the first side of the first web and to permit portions of the first web to be drawn into the cavities by a vacuum in the passages to form the array of cells projecting from the first side of the first web.

For a web having cells projecting from both sides, the forming mechanism is comprised of a first and a second rotatable cylinders each having a plurality of complementary forming regions on the surfaces thereof, each forming region on the first cylinder having a projection that penetrates into a cavity in an opposed forming region on the second cylinder as the cylinders rotate, and a cavity that receives a projection on an opposed forming region on the second cylinder as the cylinders rotate, so that a paper web passing between the cylinders forced into the respective cavities on both cylinders.

Broadly stated, a method according to the second aspect of the invention is comprised of the steps of forming an array of outwardly projecting cells on a first side of a first paper web, applying an adhesive material to the peaks of the outwardly projecting cells on the first side of the first web; and laminating a second paper web onto the glued peaks on the first side of the first paper web. The first array of cells is formed by forcing

the first side of the first paper web into contact with a surface of at least one rotating cylinder having an array of cavities on the surface thereof, and drawing the web into the cavities as the cylinder rotates by applying a vacuum through a plurality of internal passages communicating with the cavities. A second rotating cylinder in contact with a second opposite side of the paper web, and having an array of projections on the surface thereof, which are penetrable into the cavities on the surface of the first cylinder may also be employed.

A three-layer material may be manufactured by forming a second array of outwardly projecting cells on a second opposite side of the first web and laminating a third paper web onto the glued peaks on the second array of cells. Forming cells on both sides of the first web may be accomplished by engaging the first side of the first paper web into contact with a plurality of forming regions on a surface of a first rotating cylinder, engaging the second side of the first paper web into contact with a plurality of forming regions on a surface of a second rotating cylinder, causing projections on the forming regions on the first cylinder to penetrate into cavities in opposed forming regions on the second cylinder as the cylinders rotate, thereby forcing the second side of the first paper web into the cavities on the second cylinder; and causing projections on the forming regions on the second cylinder to penetrate into cavities in opposed forming regions on the first cylinder as the cylinders rotate, thereby forcing the first side of the first paper web into the cavities on the first cylinder.

A two-layer material according to the third aspect of the invention is comprised of a first layer of paper material having an array of cells thereon, the outer walls of which are formed by a first side of the first paper layer, and inner walls of which are formed by a second opposite side of the first paper layer, and a second paper layer attached to peaks of the outer cell walls on the first paper layer.

In a three-layer material, the first layer of paper material is formed into a further array of cells, the outer walls of which are formed by the second side of the first paper layer and a third paper layer is attached to peaks of the outer cell walls on the further array of cells.

The apparatus effectively allows a wide flexibility of use and adaptability to the manufacture of a multi-layer material which has reduced unit weight compared to corrugated cardboard, but which exhibits rigidity in at least two directions as well as an excellent printability. Correspondingly, the multilayer material according to the third aspect of the invention has a lower unit weight that corrugated cardboard but exhibits rigidity in at least two directions, and excellent printability.

Several other characteristics and significant advantages of the apparatus, method and material according to the invention will be shown by the following description and also with the enclosed drawings which illustrate, schematically and as an example, an embodiment of the apparatus and the material.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of apparatus for the manufacture of a first multi-layer material,

Fig. 2 is a schematic view of an installation of apparatus for the manufacture of a second multi-layer material,

Fig. 3 is a perspective view of a material structured on only one side,

Fig. 4 is a perspective view of a material structured on both sides,

Fig. 5 is an enlarged sectional view of the material of Fig. 3 structured on only one side,

Fig. 6 is an enlarged sectional view of the material of Fig. 4 structured on both sides,

Fig. 7a to 7c relate the different structures of the materials,

Fig. 8 is a view representing a box manufactured by the multi-layer material issued from the installation of Fig. 1,

Fig. 9 is a sectional view of a tool used to perform a material structured on one side and,

Fig. 10 is a sectional view of a tool used to perform a material structured on both sides.

## DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 is a schematic view of an installation for the manufacture of a first multi-layer material 13. In this figure, (there is omitted), in order to simplify the drawing, the paper feeding stations, which are conventional. These paper feeding stations usually comprise a reel stand equipped with driving and braking mechanisms and a device used to connect a new reel to the last part of a reel at the end of its unfolding to ensure the paper feeding continuity to the other stations described below.

The installation of Fig. 1 comprises a formation station 1 which produces a structured

web 2. This formation station 1 includes a cassette 3 comprising two side frames 4, 5 between which are mounted an upper cylindrical tool 6 and a lower cylindrical tool 7. These form primarily on one side, of a paper web 8 issued from a first paper feeding station (not represented), an array of staggered cells 45 as shown in Figs. 3, 5 and 7a, and described in more detail below. The lower cylindrical tool 7 is preferably connected to a vacuum source (not shown) so that the structured web 2, deformed on one side at the engaging point between the upper cylindrical tool 6 and the lower cylindrical tool 7, is maintained, by suction, against part of the circumference of the latter. An example of a tool allowing the formation of the cells 45 will be described in relation to Fig. 9.

Glue is applied to the peaks 45a of cells 45 of the structured web 2 by means of a gluing unit 9 comprising a gluing roller 10 dipping into a glue tank 11. The glue quantity laid onto the peaks of the is controlled by a drying roller 12. For obtaining a first multi-layer material 13, a second paper web 14 issued from a second paper feeding station (not shown), similar to the first feeding station, is laid onto the tops of the glued cells 45 of the structured web 2 by means of a pressing cylinder 15.

The first multi-layer material web 13 travels then around an idling cylinder 16 before it comes into a longitudinal cutting station 17. The longitudinal cutting station 17 is of conventional construction, and comprises two side frames 18 and 19 between which circular cutting tools 20 and 21 are mounted. The circular cutting tools 20 are made of circular blades adjustably secured, into the width of the longitudinal cutting station 17, in order to obtain first multi-layer material webs 13 of different widths. The side cut of the first multi-layer material web 13 is also completed in this station.

The circular cutting tool 21 generally comprises an anvil tool with adjustable sleeves, into the width of the longitudinal cutting station 17, said sleeves showing circular grooves, which can be located at the opposite side of the circular blades of the circular cutting tools 20. In one particular kind of longitudinal cutting machine, the circular cutting tool 21 can be shaped like an anvil cylinder covered, for example, with a material such as polyurethane.

The first multi-layer material web 13 is then introduced into a transverse cutting machine 22, also conventional, comprising two side frames 23 and 24. The transverse cutting machine 22 comprises, first of all, an upper rotary tool 25 provided with a knife, generally helocoidally shaped knife, and a lower anvil cylinder 26 which can either be formed of steel, and if desired,

covered with polyurethane. As may be understood, the higher rotary cutting tool is actuated in order to carry out cuttings of different lengths of the first multi-layer web 13, in accordance to the various required formats. At the output of the longitudinal cutting station 22, sheets 27 of the first multi-layer material 13 are conveyed on a belt conveyor 28 to a stacking station 29, schematically represented here by a device comprising a piling member 30 able to form a pile 31.

Fig. 2 is a schematic view of an installation for the manufacture of a second type of multi-layer material 40 having arrays of cells on both sides. The installation of this figure is different from the one represented on Fig. 1 in that different cell forming tool is used, and in the addition of a station 32 to apply a second cover web so that the resulting multi-layer material is comprised of an inner cellular layer with covering layers on both sides. The common elements of both embodiments have the same numerals.

In Fig. 2, there are omitted, in order to simplify the drawing, the conventional paper feeding stations as described in connection with Fig. 1.

The installation of Fig. 2 also comprises a formation station 1 for a web 34 structured on both sides. This formation station 1 includes a cassette 3 with two side frames 4, 5 between which two cylindrical upper and lower tools 6 and 7 are arranged and intended to form, on both sides of a paper web 8 issued from a first paper feeding station (not represented) arrays of cells 46 and 47 on opposite sides 48 and 49 of a web 34 as illustrated in Figs 4, 6 and 7b-7c, and described in more detail below.

The lower cylindrical tool 7 is preferably connected to a vacuum source so that the structured web 34 deformed at the engaging point between the upper cylindrical tool 6 and the lower cylindrical tool 7 is maintained, by sucking, against part of the circumference of the latter. An example of a tool allowing the formation of the structured two-sided web 34 will be described in relation to Fig. 10. Glue is applied to the peaks of the cells on the radially outer side of the structured web 34 located in the suction circumference area of the cylindrical tool 7 by means of a gluing station 9 including a gluing roller 10 dipping in a tank 11. The glue quantity is controlled by means of a drying roller 12. This gluing unit 9 can either use a starch-based glue or a vinyl glue. A second paper web 14 issued from a second paper feeding station (not represented), identical to the first feeding station, is laid onto the glued peaks of one side of the structured web 34 by means of a pressing cylinder 15. The multi-layer material web 35 travels then around

an idling cylinder 16 before being conveyed into an insertion station 32 by which a cover web 33 issued from a third paper feeding station (not represented), identical to said first and second feeding stations is applied to the opposite side of web 34. Glue is applied to the peaks of the cells on the other side of the structured web 34 by means of a gluing unit 36 identically arranged as the gluing unit 9. This gluing unit also can either use a starch-based glue or a vinyl glue. The gluing roller 38 of this gluing unit 36 deposits glue on web 34 as it passes over the idling cylinder 16. The glued peaks are then brought into contact with the cover web 33 by means of the pasting down cylinder 39. The resulting three-layer material 40 is then conveyed onto a pressing device 41 including a table 42 and a pressing device equipped with a range of rollers 43. It is obvious that several of these pressing devices 41 may comprise a belt conveyor instead of a feed table 42.

The web of the second multi-layer material 40 is then conveyed into a longitudinal cutting station 17 identical to that of Fig. 1, and comprised of two side frames 18 and 19 between which circular cutting tools 20 and 21 are positioned. Circular cutting tools 20 are made of circular blades adjustably secured in the width of the longitudinal cutting station 17, for obtaining multi-layer material webs with different widths. The side cutting of the second multi-layer material web 40 is also achieved in this station.

Circular cutting tool 21 is in opposed relation to tool 20, and comprises adjustable sleeves, arranged in the width of the longitudinal cutting station 17, the sleeves having circular grooves which can be located opposite to the circular blades of the circular cutting tools 20. In some instances, the circular cutting tool 21 can be shaped like a cylindrical anvil covered, for example, with a material such as polyurethane.

The web of the three-layer material 40 is then introduced into a transverse cutter 22 which comprises two side frames 23 and 24. This transverse cutter 22 is also conventional. It comprises an upper rotary tool 25 equipped with a blade, usually helicoidally shaped, and a lower anvil cylinder 26 which is formed of steel and may be covered with polyurethane. As will be understood, upper rotary cutting tool 25 is driven, and cuts web 40 to different lengths, according to different required formats. At the output of the transverse cutting station 22, sheets 44 of the three layer material 40 are conveyed on a belt conveyor 28 up to a stacking station 29, schematically represented here by a device comprising a piling member 30 intended to farm a pile 31. The stacking stations are also conventional, and will thus not be described in detail.

It will be understood that paper web 8 having to be formed, will be accordingly humidified in the same way as it is the case for corrugated cardboard production machines.

Fig. 3 is perspective view of a material 2 ,structured on one side. Said structure is made of cells 45, issued for example from the tool which will be described further related to Fig. 9.

Fig. 4 is a perspective view of a material 34 structured on both sides. The structure represented here is made of cells 46 and 47, issued for example from the tool which will be further described related to Fig. 10.

Fig. 5 is an enlarged sectional view of material 2 of Fig. 3 only structured on one side 48, i.e. in which an array of cells projects only from side 48.

Fig. 6 is an enlarged sectional view of material 34 of Fig. 4 structured on both sides 48 and 49. i.e. in which arrays of cells projects from both sides 48 and 49.

Fig. 7a to 7c show the structure of materials 2 and 34.

Fig. 8 is a view representing a box 50 manufactured by the multi-layer material 13 issued from the installation of Fig. 1. This box 50 is an example of the use of a multi-layer material 13 with an aesthetic appearance related to the promotion of a product. A possible use for advertising material is also intended. Obviously, such results cannot be reached by using a multi-layer material like corrugated cardboard for the reasons indicated above.

Fig. 9 is a partial sectional view of a tool 51 used to form a material 2 structured on one side 48. This tool 51 comprises an upper cylinder 52 having projections on its surface and a lower cylinder 53 having cavities in its surfaces. The projection penetrate the cavities and deform the paper web 8 and thus obtain a web material 2 structured on its side 48. The lower cylinder 53 is arranged to ensure the maintenance of the textured web material 2 in the cavities against its circumference, by means of channels 54 connecting each cavity to the empty central part of cylinder 53 connected itself to a vacuum source (not represented). In case of structures with more significant thickness, it will be necessary to heat the tool 51 up to a temperature of about 300° centigrade for obtaining a structured web material 2 with a structure of low thickness, it is not necessary for the tool 51 to reach a high temperature. For structures with very low thickness, e.g. about 0,2 to 0,6 millimeter, one can employ a more simple tool 51 using only one lower cylinder 53 connected to a powerful vacuum source so that the vacuum action on the paper web 8 at the bottom of the cavities produces the required deformation for obtaining the structured material web 2. The upper and lower cylinders can be easily formed,

for example, by an electro-erosion process.

Fig. 10 is a sectional view of a tool 55 used to form a structured material 34 having cells on both sides 48 and 49. This tool 55 comprises an upper cylinder 56 and a lower cylinder 57. Forming regions on the two cylinders each have cavity regions and projecting regions shaped to penetrate each other and deform the paper web 8 to create a structured web material 34 having cells on both sides 48 and 49. The lower cylinder is arranged for maintaining the textured material web 34 at the bottom of the cells of part of its circumference,-and thus by means of channels 58 connecting each cell to the grooved section in the middle of the cylinder 57 connected itself to a vacuum source (not represented). For obtaining a structured material web 34 with a low-sized thickness structure, it is not necessary for the tool 55 to reach a high temperature. In case of greater thickness structures, it will be necessary to deal with the heating of the tool 55 up to a temperature of 300° centigrades. For very slight thickness structures, of about 0,2 to 0,6 millimeters, one can deal with a more simple tool 55, as for the tool 51 of Fig. 9, using only one lower cellar cylinder 57 connected to a powerful vacuum source so as the vacuum action on the paper web 8 at the bottom of the cells causes the required deformation for obtaining the structured web material 34. The achievement of the upper and lower cellar cylinders can advantageously be carried out for example by an electro-erosion process.

The above mentioned installation for the manufacture of a multi-layer material allows, among others, obtaining, if one uses a web structured on both sides with a special decorative printing, as the ones shown for example on Fig. 7a to 7c, an embossing multi-layer material, which offers a wide range of use of this material either for an ornamental supply or another one.

In describing the invention, specific terminology has been employed for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents that operate in a similar manner to accomplish a similar purpose.

Similarly, the embodiments described and illustrated are also intended to be exemplary, and various changes and modifications, and other embodiments within the scope of the invention will be apparent to those skilled in the art in light of the disclosure. The scope of the invention is therefore intended to be defined and limited only by the appended claims, and not by the description herein.